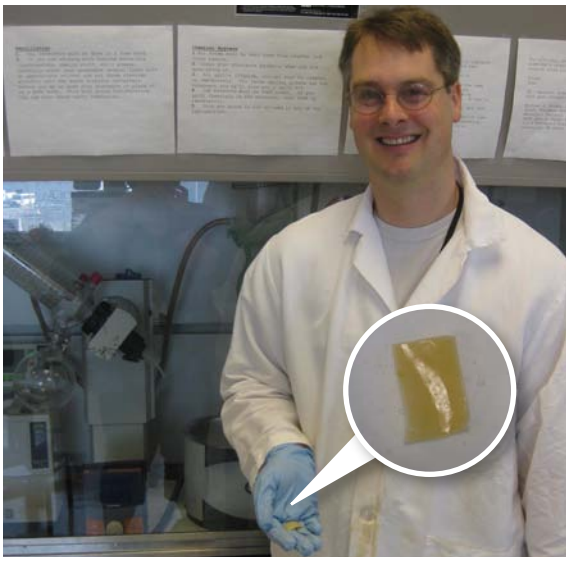
National Aeronautics and Space Administration

technology opportunity

Advanced Copolymer Gel Electrolyte Enhances Lithium Ion Batteries



NASA's Glenn Research Center invites companies to license an advanced copolymer gel electrolyte that enhances the performance of lithium ion batteries. The NASA electrolyte is a polyimide-polyethylene oxide (PEO) rod-coil copolymer gel with a highly cross-linked three-dimensional structure. Cured at room temperature, the gel can hold over four times its weight in liquid additives, accommodating both conventional carbonate solvents and room-temperature ionic liquids. The technology enables a safer, highly flexible, and environmentally friendly fabrication method for producing batteries with high ionic conductivity, high cycling stability, mechanical strength, and potentially increased cycle life.

Benefits

- **Flexible processing:** Can accommodate both ionic and organic liquids
- **Simplified fabrication:** Straightforward synthesis method is versatile and can be performed at low temperatures
- **Increased operating temperature range:** Provides high ionic conductivity at ambient and high temperatures; enables use at sub-ambient temperatures by employing solvents
- **Improved safety:** Implemented without use of volatile organic compounds, making it safer and more environmentally friendly
- **Improved conduction and battery life:** Copolymer holds more than four times its weight in liquid additives, significantly aiding in the conduction of ionic species and potentially increase the battery cycle life
- **Dimensionally stable:** Cross-linked rod-coil structure and aluminum oxide nanoparticles confer mechanical strength
- **Low interfacial resistance:** Aluminum oxide nanoparticles give an order of magnitude improvement at electrode interfaces

Applications

This electrolyte technology would enhance the performance of rechargeable lithium ion polymer gel batteries in applications such as:

- Wafer-thin geometries such as batteries for "smart cards"
- Portable electronics such as cell phones, personal digital assistants (PDAs), laptops, digital music devices, and wireless controllers
- Battery-powered robots
- Lightweight radio-controlled cars and aircraft
- Grid power storage (for example, storing solar power during the day for use at night)
- Portable tools
- Automobile batteries

For More Information

For more information about this and other technology licensing opportunities, please visit:

Office of Technology Partnerships and Planning
NASA's Glenn Research Center
E-mail: ttp@grc.nasa.gov
Phone: 216–433–3484
http://technology.grc.nasa.gov

Technology Details

This technology was developed to address the limitations of lithium-based polymer batteries used in aerospace applications, which need to work at temperatures ranging from -70°C to +70°C. Current state-of-the-art solid polymer PEO-based electrolytes, however, only have acceptable ionic conductivities above 60°C. With a lithium salt dissolved in an ionic liquid, NASA's new electrolyte gel has ionic conductivity exceeding 10-3 siemens/cm at room temperature. Aluminum oxide nanoparticles can be incorporated into the polymer gel electrolyte film to improve electrode kinetics by an order of magnitude.

How It Works

This technology consists of a composite material with the cross-linked structure of the copolymer, which creates nanoscale voids. The void space is filled with a liquid, and when ionic liquids are incorporated, an increase in ionic conductivity of two orders of magnitude can be achieved.

Diamine and dianhydride are reacted and cured in solution to produce an amine end-capped oligomer. The reaction with a trifunctional molecule yields a fully three-dimensional, cross-linked polymer web. The rod-coil copolymer is believed to exhibit a higher liquid uptake than any other material known in a lithium-ion battery.

Why It Is Better

PEO (and materials based on PEO) is a traditional polymer electrolyte in lithium-ion batteries. However with conventional PEO, lithium ion conductivity is two orders of magnitude too low for advanced battery designs. Also, PEO melts at temperatures above 80°C and does not have good dimensional stability.

Other gel electrolytes for lithium batteries are made from Polyvinylidene Fluoride, which has a less flexible matrix, is less environmentally friendly, and is typically more expensive to manufacture. NASA's new versatile polymer synthesis fabricates easily and offers the flexibility of making a highly conductive electrolyte with either no volatile components (when an ionic liquid is added) or with an added solvent. With no volatile components, the fabrication process is safer and the batteries have high lithium ion conductivity at ambient to high temperatures. By adding solvents, high lithium ion conductivity can be achieved at sub-ambient to ambient temperatures.

The copolymer has a large capacity, holding more than four times its weight in liquid. Its high ionic conductivity improves lithium ion conductivity over a wide temperature range (particularly at room temperature) and enhances battery usefulness. Its cross-linked rod-coil structure and aluminum oxide nanoparticles confer mechanical strength with low interfacial resistance that produces an order of magnitude improvement at electrode interfaces.

Patents

Glenn has issued and pending patents on this technology (U.S. Patent Nos. 6,855,433, 6,881,820, and 7,704,622).

Licensing and Partnering Opportunities

Glenn's Office of Technology Partnerships and Planning seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the Advanced Copolymer Gel Electrolyte suite of technologies (LEW-18205-1, LEW-18394-1, LEW-17750-1, LEW-17299-2, LEW-17721-1, LEW-17592-1) for commercial purposes.

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